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REMARKS ON THE BRAIN OF THE SEALS.

BY E. C. SPITZKA.

ENGAGED for many years in collecting material for a monograph on the "Marine Mammalia," whose publication has been delayed by the obtaining of new specimens from unexpected sources, and partly by the desire to publish only well-matured and verified observations, I find myself compelled to anticipate my projected paper, in order to correct the manifest errors of the latest publications on this subject.

Dr. Fritz Theodor[1] makes the startling discovery that in the *Phoca* (*Calocephalus*) *vitulina* there is between the two cerebral hemispheres, dorsad of and separated by a gyral interval from the callosum, a second commissure, extending cephalo-caudad nearly as much as that great fiber-bridge. Such an observation would revolutionize all ideas hitherto accepted as to the signification and relations of the callosum, not to mention the peculiar position which such a profound deviation from the mammalian cerebral type would lead morphologists to assign the *Phocidæ*.

On examing Theodor's plate (x., Fig. 4) I find that his so-called "commissura suprema" is the saddest kind of a delusion. In making a medi-section of his seal's brain he sliced off a mesal gyrus, and, deceived by the cut surface, hastily assumed it to be a commissure. How carelessly this was done becomes evident on regarding his Figure 5 (Plate VIII.), where the cortical and gyral structure of the so-called commissure are apparent. Now, lest it might be assumed that he had a monstrosity[2] to deal with in a single specimen, we find that he had two, a younger and an older seal; and furthermore, his artist (Plate IX., Fig. 6) omits the so-called new commissure, furnishing a rather correct representation as I have found it in three brains of the same species.

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[1] Das Gehirn des Seehundes (*Phoca vitulina:* Dr. Fritz Theodor, Freiburg i. B., 1887. (The Brain of the Common Seal, by Dr. Frederick Theodor.)

From a thorough examination of the brains of two sea-lions (*Zalophus Gillespieii*) and three seals[3] (*Phoca vitulina*), I may state the following: The number and complexity of the gyri on the mesal face of the seal's and sea-lion's brain is as great as in the anthropoid brain, and in the frontal region rather more so. Where the falx does not intervene, the gyri are bound firmly together by the leptomeninges. Like all complexly convoluted brains, that of the seal shows considerable asymmetry. In transsection it can be readily seen, even in the sea-lion's brain, that the apices of the gyri of one side interdigitate with the gyri of the other, so that a strictly median section might shave off the former. If we add to this the presumable[4] distortion to which such a complex brain is necessarily exposed during its removal, the likelihood of such an occurrence becomes greatly increased.

If the intrinsic evidence of Theodor's paper, which is really self-condemnatory, did not suffice to show the fallacy of his claims of a *commissura suprema*, I would add the following:

1. In six phocidæ I have exposed the callosum from the mesal fissures, found it contrasting in its brilliant white with the deep gray, or rosy gray (according to age and species) of the cortical surface, as markedly as in man or the anthropoid apes.

2. I have found no other commissure dorsad of it, nor any

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[2] Mesofusion of the gyri occurs in monstrosities with absent callosum and absent falx.

[3] A fourth seal was less perfectly studied, owing to the decomposition of part of the brain, although it also confirmed the gross points herein detailed. With the exception of that specimen, which I owed to the N. Y. Aquarium, and one purchased at a fishmonger's, all were obtained through the kindness of Dr. Conklin, Superintendent of the Central Park Menagerie, in a perfectly fresh condition, being removed from the animals within a few hours after their decease.

[4] We should hesitate to assume this if the very figures of Theodor did not positively prove manipulation to have far exceeded the allowable.

fusion of the mesal gyri, nor anything that could remotely suggest even a spurious commissure of the cerebrum.

3. I have made trans-sections of the seal's and sea-lion's brain (the latter being preserved and accessible), and found one, and but one, great[5] transverse commissure uniting the interior white substance of the two cerebral hemispheres of the phocidæ.

If his announcement, on so defective a basis, contradicted by the author's own artist, and positively controverted by careful observation, did not suffice to expose the fallacy of his revolutionizing[6] discovery, the collateral evidence involved in the exposure of the following errors would inculcate the need of caution in accepting the radical propositions with which his paper closes.

He states that the seal has no olives in the sense of the human olive. The seal is, however, noteworthy for the large size of the olivary protuberances. Theodor, in his wretched figure (Plate VIII., Fig. 2), represents the pyramidal columns of the oblongata as showing a roundish swelling laterad. It is to-day generally known to neuro-morphologists that the true pyramids are fascicular, that they can therefore exhibit no enlargement, followed by attenuation, except it be due to a spreading of the fibres, or the inclusion of some other body, such as a ganglion or a commissure. In the sea-lion the same enlargement is distinctly demarkated from the pyramid tract, although not much larger than in the bear. In the sea-lion, as in the bear and other land-carnivora, the hypoglossal nerve roots emerge laterad of the olivary eminence. In man and true apes they emerge mesad of the olive in the groove between the latter and pyramid.[7] In the true seals (*Phoca vitulina*) they emerge partly in the latter situation, and partly from the olivary eminence itself, thus showing a sort of transitional state. Tiedemann,[8] sixty-eight years ago, in a plate which for accuracy puts those of Theodor to the blush, represents the hypoglossal nerve taking the origin I have ascribed to it, omitting, however, the most cephalic rootlets, which are indeed very frail. Since Theodor cites Tiedemann, it is remarkable that he could have borne the latter's excellent plates in mind, and in conflict with the real facts designated the first cervical as the hypoglossal pair (Plate VIII., Fig. 2).[9] In removing the membrane it is very difficult to avoid tearing off the hypoglossal nerve roots, and it is doubtless due to this fact, and his erroneous naming of the first spinal as the last cranial nerve, that Theodor's non-recognition of the olive is due.

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[5] I need not add that I found the pre-commissure developed, and though small, disproportionately to the atrophic olfactory lobes.

[6] It is but doing justice to the author to state that he seems to have been entirely unaware of the bearing of this alleged discovery.

[7] Trans-sections of the oblongata show a tendency of the hypoglossal nerve roots in man to break through the olive proper, but on the ectal face they are collected in a common fascicle.

Although the older writers, particularly Tiedemann, have carefully delineated and described lobules of the cerebellum, and especially its vermiform lobe, Theodor in one sentence states that the seal has no *vermis cerebelli* in the sense in which a *vermis* is spoken of in the human cerebellum, and in another proceeds to describe it to be an exceedingly complicated body. Much dependence cannot be placed on his dissections and figures. I have never been able to remove a phocidan cerebellum intact without sacrificing the skull; for the lobulus appendicularis, measuring fully half an inch cephalo-caudal, as much transversely, and one-quarter of an inch dorso-ventral, is almost entirely embedded in bone, and connected with the main cerebellum through a small foramen by a pedicle not exceeding a line in diameter. Theodor has failed to preserve this morphologically important structure, and even to discover his failure to do so, although the most superficial acquaintance with the dog's or cat's brain should have directed his attention to it, particularly in view of his sweeping conclusions as to the phylogeny of the marine and terrestrial carnivora.[10] These are expressed as follows: "The seals and (ordinary) carnivora are in their cerebral organization to-day widely separated, and their common origin must be sought in a remote geological period." [Pp. 90–91.]

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[8] *Icones cerebri simiarum et quorundum mammalium rariorum,* Heidelbergia, MDCCCXXI., Plate II., Figs. 7 and 8. It is to be remarked that Tiedemann attributes olives (*olivæ vix conspicuas*) to the seal, but locates the figure reference laterad of these bodies. The trapeziums he correctly recognizes.

[9] While Tiedemann accurately exhibits the decided caudal direction of the cervical nerves from their origin, which is in remarkable contrast with that of the transversely running hypoglossal, Theodor tilts his nerve roots in the opposite direction. In every respect his figures are far behind Tiedemann's as to accuracy and interpretation.

Now the fact is that an examination of a series of brains beginning with the mink, the fresh-water and salt-water otter, and passing through the eared to the earless seals, would show about as beautiful a transition as a morphologist could well desire. It is misleading to establish a type in a specialized form. The Canidæ and Felidæ are as specialized in this way as the Phocidæ; the Viverridæ, particularly the Ursidæ are more typical carnivores. And on examining a bear's brain, Theodor would have found the same peculiarity of the Island of Reil he found in the seal, excepting the feature due to the peculiar vertical course of the Sylvian fissure in the latter.

Anticipating the more complete monographic publication now in preparation, and which it is intended to illustrate by photographs and other reproductions of both external and internal details, I would summarize the characteristic features of the seal's brain as follows: (1) It is a typical carnivore brain in every essential feature. Morphologically it does not present a single deviation from the type. All differences are due to the relative preponderance of some and relative atrophy[11] of other parts. Thus the olfactory lobe is reduced to such an extent that in some individual common seals the tract is deeply imbedded in the sulcus, and even invisible in a part of its course, unless the sulcus be opened. In harmony with this the hippocampal lobule is relatively reduced, and remarkably flat. The auditory nerve is enormous, and with this the therewith connected trapezium, lemmiscus lateralis, posterior pair of the corpora quadrigemina and internal geniculate bodies are overgrown. There is a microscopically visible fluted tract on the caudal aspect of the thalamus running ectad from the latter bodies to the auditory cortical field of the hemisphere. It is the enormous hypertrophy of this field which crowds the Sylvian into its unusual vertical, nay, actually anticlinal, position.[12]

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[10] It seems almost comical that this author, convicted of gross inaccuracies both in his methods, observations and interpretations, should venture upon one criticism of the far more accurate and venerable Tiedemann, in which the former is precisely wrong. He states that the diameter of the Trigemius nerve is exaggerated by him as well as by Gratiolet. It so happens that my measurements in three individuals equal those of the latter, and slightly exceed those of the latter observer.

[11] In brain morphology one must distinguish between physiological peculiarities and intrinsic zoological features. Thus the atrophy in some and absence in other cetaceans of the olfactory bulb is a physiological atrophy; whereas the absence of the epiphysis cerebri would be a profound zoological anomaly. The greater or lesser size of the pyramid tract is in direct physiological parallelism with the voluntary innervation of extremities endowed with prehensile movement, and their absence, presence or development has not such profound significance as has the gyral *type* of the hemispheres, the cerebellum and the olives. It would be possible, therefore, to offer a classification of the higher mammalia based on the *type* of olivary or cerebellar coruscations; whereas the degree of pyramid development would be a less important determining factor.

One of the most interesting proofs of the value of neuro-morphology in classification is offered by a comparison of the brains and spinal cords of the Cetacea,[13] Sirenia,[14] and Phocidæ. The phocidan brain is, as above stated, a physiologically aberrant, but morphologically genuine carnivore brain. The manatee has the brain of a hippopotamus. The Cetacea, in accordance with their to-day isolated position, have the most aberrant central nervous system of all, but to no other brain do they approach so nearly as to that of the Proboscidia, a group which, with the possible inclusion of other extinct and recent related forms, approaches more nearly the common ancestral trunk from which so widely divergent branches have sprung.[15] Zoological characters

[12] In reality the position of this fissure is dependent on two factors: the lower, corresponding to the cephalic part of the human, has sunk ventro-caudal through the retrogression of the sphenoidal lobe, and the upper (posterior part of the human) has been driven dorso-cephalal by the overgrown auditory cortical field. The same general impression can be conveyed by tilting the tempero-occipital lobe of a putty model of a bear's brain into a foreshortened skull model. Thus the frontal lobe will come to resemble the square and compact contour of the seal's brain. That such a mechanical process has been undergone by the latter is demonstrated by the evident violence to which the olfactory tracts and lobes have been subjected. In no other carnivores are the bulbs so far cephalad and the tracts bodily driven into the depths of the *sulcus rectus*.

[13] A decayed Beluga's brain, and a Phocæna from the N. Y. Aquarium, two beautiful ones of *Tursiops tursio* and one of *Delphinus delphis*, through Mr. Eugene Blackford, of this city. To Professor Wm. F. True, of the Smithsonian, I am indebted for aid in determining the species.

[14] The brain axis and cord of Professor Wilder's specimen, loaned by him.

[15] In stating this I am not misled by the superficial characters, such as the richness in gyri, or in fact any quantitative features. I am determined by the *type* of gyral development, the type of cerebellar foliation, and the character of the olive, which is of the

are more numerous, constant, and of classifying value in a complex organ such as the brain than in the spinal cord.[16] Yet even in this comparatively simple organ specific differences of structure are found, and accordingly the most atypical form is represented in the Cetacea. The ventral horn of gray matter is immensely overgrown, and the dorsal correspondingly atrophic; there is an enormous lateral horn present. On first sight this would appear to be an entirely novel structure, peculiar to the Cetacea; further examination shows that it is homologous with, though an overgrown representative of, a cell-group present in other mammals, which owes its prominence and peculiar position to the following factors: (1) The shrinkage of the neck of the dorsal cornu acts on the extreme ventral and lateral parts of the ventral horn as would the passing of an elastic band around a group of matches, spreading their ends apart; (2) the absence of the pyramid tract in the dorsal part of the lateral column causes an encroachment of the ventral part of the lateral column; (3) the dorsal (posterior) white columns are relatively reduced. To convert a human cord into a porpoise's there must be imagined a shrinkage of the posterior or dorsal white and gray matter, as well as the posterior or dorsal part of the lateral column, in other words, of the entire part of the cord which would lie behind a transverse line which in man leaves nearly as much in front (ventrad of) the central canal as behind (dorsad of) it. This line in the Cetacea would be a curve, and in accordance therewith the outline of the cord in the latter is not nearly circular or a rounded quadrangle as in man, but heart-shaped, the apex being represented by the shrunken posterior or dorsal segment, the bifurcate base by the overgrown halves of the ventral or anterior segment.[17] Although this remarkable deviation is in

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compact, massive kind, in contradistinction to the slender lamina type characteristic of rodents, carnivores, apes and man, and whose higher development leads to crenulation. The increase of olivary ganglionic matter in the elephant and porpoise is by aggregation in bulk without crenulation; yet the latter presents true Ungulate features.

[16] The spinal cord of the gorilla in the dorsal region (Waldeyer) shows characters not found in the human cord, a fact long known to me, though not published, from the case of the chimpanzee.

[17] Guldberg has partly observed this, but many years subsequently to my published observations, with which he seems to have been unacquainted.

part due to physiological reasons, yet it is in so far a zoological one as the whole "physiognomy" of the dorsal segment of the cord in the Cetacea is more like that of the Ungulata than the Carnivora. A section of the spinal cord at the level of the foramen magnum has, in every genus, something distinctive, in every family something quantitatively different from other families, in every order something qualitatively and radically distinguishing it from nearly related orders. While, as already stated, such differences have not the profound morphological meaning which certain cerebral features possess, yet it is not from attaching any over-importance to the field to which I have devoted most of my dilettante studies that I venture to prophesy that when the minute and coarse anatomy of the nerve axis be once thoroughly known for each species it will be possible to offer a more correct classification of the Mammalia than any now extant, or any other based on a single criterion. It would not be difficult to enunciate many valuable data for classification furnished by a study of the nerve centres in Sauropsida and Ichthyopsida. Many peculiarities of the appendages of the brain among the former, such as the cartilaginous epencephalic hood of the Chelydra, and the cartilaginous rod attaching the oblongata to the basi-occipital bone in Thalassochelys, require and will repay further study. It is in view of the importance of registering only correct observations that I offer this provisional correction of such revolutionary pseudo-discoveries as those above criticised.

PLATE III.

Fig 1

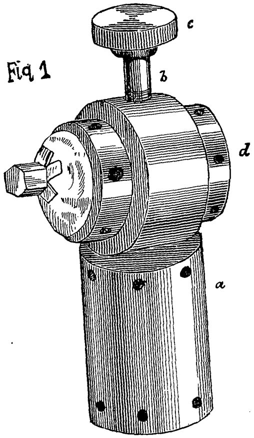

Fig. 2

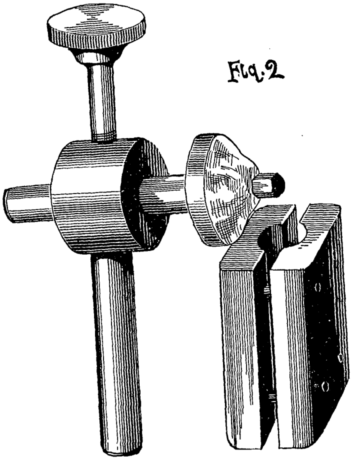

PLATE IV.

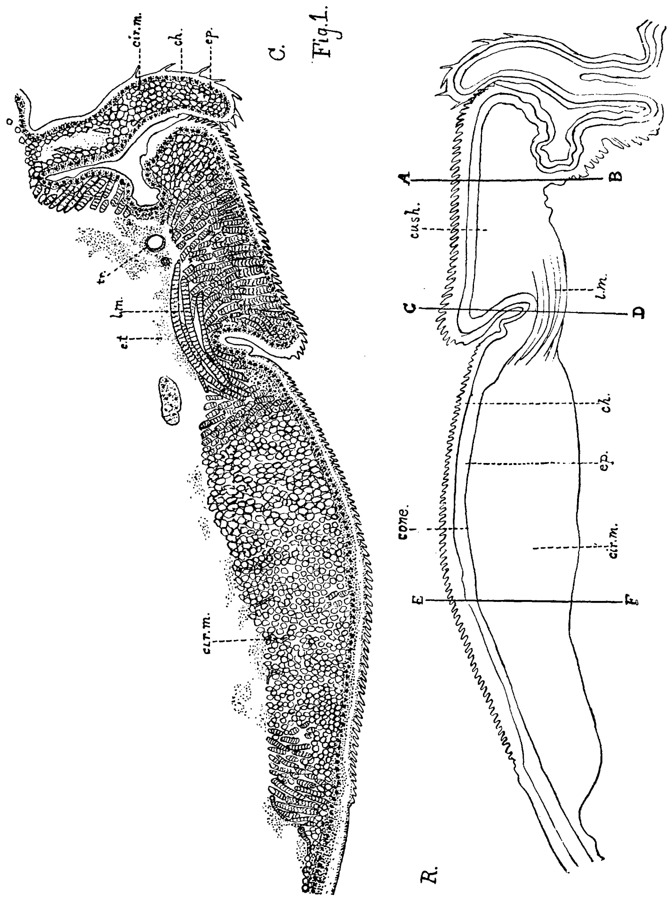

Fig. 1.

PLATE V.

Fig 2.

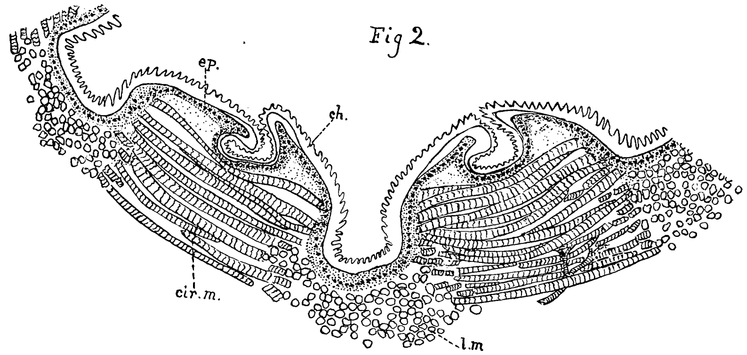

Fig. 3.

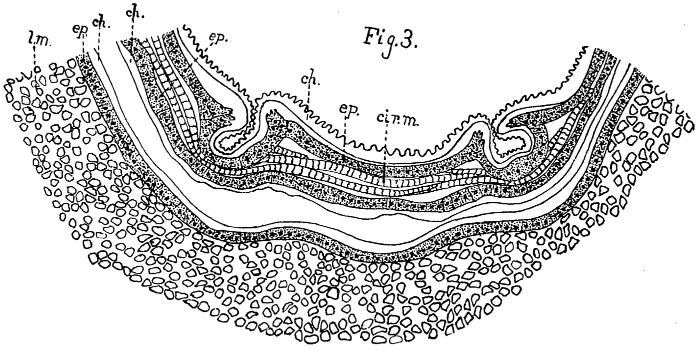

Fig. 4